CANMET

Canada Centre for Mineral and Energy Technology

Centre canadien de la technologie des minéraux et de l'énergie

Energy Research Laboratories

Laboratoires de recherche sur l'énergie

Canada

Energy, Mines and Resources Canada

Énergie, Mines et Ressources Canada

90-03966/

ACCELERATED SAMPLE PROCESSING 1988-89 PHASE III NORTHEAST COOPERATIVE WOODSTOVE STUDY

FINAL REPORT

Part of the Program of the Federal Panel on Energy R&D (PERD).

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MICROMEDIA

PRELIMINARY RESULTS: 1988-89 NORTHEAST COOPERATIVE WOODSTOVE STUDY

INTRODUCTION

The Northeast Cooperative Woodstove Study, conducted over a three month period this past winter, measured particulate stack emissions using the AWES sampling system from 25 new-technology stoves installed in homes in the Glens Falls, N.Y. area. Five stove brands, three catalytic and two non-catalytic, were selected for the study based on their performance in a laboratory durability test. Each stove brand was represented by five stoves. The catalytic stoves were represented by the Blaze King Royal Heir, Country Flame BBF and the Oregon Woodstove. The non-catalytic stoves were the Country Comfort CC150 and the mid-size Regency .

Each stove was sampled for five weekly periods spanning from early January to late March. This type of sampling schedule provided an opportunity to document trends in stove emissions over the heating season as well as average performance.

RESULTS

Average Overall Performances

Figure 1 shows that the average particulate emissions for the burning season from the best performing catalytic woodstove brand, Country Flame, was about 5 grams per hour. This represents a 75% decrease in emissions compared to conventional woodstoves and nearly as great a reduction over results from previously studied in-home catalytic stoves.

The emissions levels for all of the other four stoves' were about twice the Country Flame's, ranging from about 9.6 to 13 grams per hour.

The burn rates for the five diverse stove models were quite similar, ranging from 0.94 to 1.27 dry kilograms per hour (Figure 2).

Trends

General trends of the five stove brands : There has been concern that the performance of new technology stoves, catalytic stoves in particular, degrade significantly over time and that emissions over a stove's lifetime could be highly elevated compared to new stove values.

Figure 3 shows trends of emissions performance degradation over the three month sampling period for the populations of the three catalytic stove brands. The Country Flame displays a slight upward trend, but a "T" test does not substantiate a statistically significant trend. However, the upward trend for the Blaze King is significant at the 95% confidence level. The performance of the Oregon Stoves was erratic. Unfortunately, the bypass mechanism in these stoves did not consistently shut, causing highly variable, unstable performance. The effects of this variable are apparently so strong as to mask effects of other variables.

The two non-catalytic stove brands display an unchanging level of performance throughout the testing period (Figure 4). The plot of the CC150 without the homeowner Bobst is considered most representative for that stove since Bobst used the stove in an earthen house at a burn rate about one half that of the next lowest participant in the study.

Individual stove trends: Blaze King. Four out of five Blaze Kings display performance degradation (Figure 5). Evaluation of the causes of this performance degradation were made by field inspecting all stoves after the burning season. Measurements, photographs and VCR tapes were made. A summary of some of the significant stove-by-stove findings follows.

Stove 2 developed sagging and oxidation in the front section of the bypass support creating an opening of 5/8". The cause of performance loss is at least partially attributable to this structural failure.

Stove 25 has no bypass sagging or warping. No leaks around the catalyst or in the firebox are present. Loss of catalyst function is the most probable cause of emissions degradation. Catalyst brand is Panasonic.

Stove 23 has minor (0.160") bypass sag in the front center but ash is present sealing the opening. Loss of catalyst function is the most probable cause of emissions degradation. Catalyst brand is Panasonic.

Stove 12 has slight (0.090") bypass sag in the front center but ash is present sealing the opening. Loss of catalyst function is the most probable cause of emissions degradation. The catalyst, a Corning, has undergone washcoat flaking to a depth of 1" in the front center portion and to a depth of 1/4-3/8" in the back.

The Blaze King stove design appears to cause early failure of catalysts. At least three catalysts are in some degree of failure. Additionally, the lack of structural support for the bypass allows sagging to occur in the frontal section eventually leading to significant leakage. Three bypasses are in various stages of failure.

Individual stove trends: Country Flame. Only one of the Country Flame stoves experienced performance degradation, stove 13 (figure 6). The maximum bypass gap is only 0.055", low for this stove, and no other leaks are evident. Loss of catalyst function is the most probable cause of emissions degradation.

The Country Flame stove design appears to prolong catalyst life comparatively well. Followup testing of these stoves' performance after two and possibly three heating seasons would better evaluate the potential lifetime emissions performance of this stove.

The bypass construction in this stove is highly effective. All bypasses appeared to be sealing well at the end of the heating season. Little if any sag developed. The largest bypass gap is 0.100".

Individual stove trends: Oregon Woodstove. Due to the problems homeowners had with closing bypasses, trend analysis is difficult to conduct (Figure 7). Additionally, two stoves had significant bypass gaps even when completely "closed". These stoves will be discussed first.

Stove 22 had a bypass gap of 0.625" on the right opening and 0.125" on the left opening. These gaps were already present by mid January. The bypass closing mechanism was relatively inconsistent and sticky. The poor performance of this stove demonstrates the degradation that can occur from having a bypass defect of this magnitude. Emissions were always greater than 11 and ranged up to over 26 grams per hour.

Stove 9 is a similar but less extreme situation. Bypass gap was 0.175" on the right and tight on the left. Emissions ranged from 11 to 14 grams per hour.

Stove 5 had tight bypasses but a sticking mechanism in mid January. A bypass gap developed during the season that eventually reached 0.100" on the right. This change might explain the apparent increase in emissions.

Stove 3 had quite tight bypasses throughout the season. At the end of the season the right gap was 0.050". Emissions performance displays little variation and was relatively good.

The Oregon Woodstove's quality control problems with bypass gaps and sticking mechanisms cause a significant loss in performance. Unfortunately, the presence of these problems did not allow for an evaluation of the performance of the stoves' catalysts.

Individual stove trends: Regency. None of the Regency stoves appears to have developed a trend in emissions performance (Figure 8).
However, physical degradation is evident in three of the stoves. The baffle plate is significantly oxidized in stoves 20, 24 and 16 and warped in stoves 20 and 16. This is evidently not affecting performance but the removable baffle would need replacing at some point in time.

Individual stove trends: Country Comfort CC150. None of these stoves appear to have developed a trend in emissions performance, but a large amount of variation is present (Figure 9).

Physical degradation of two of the stoves is evident. The lower part of the backplate that the bypass closes against is oxidized and flaking in stove 8. In stove 21 it also warped 5/8" producing a bypass leak. Emissions performance did not suffer in this stove, however.

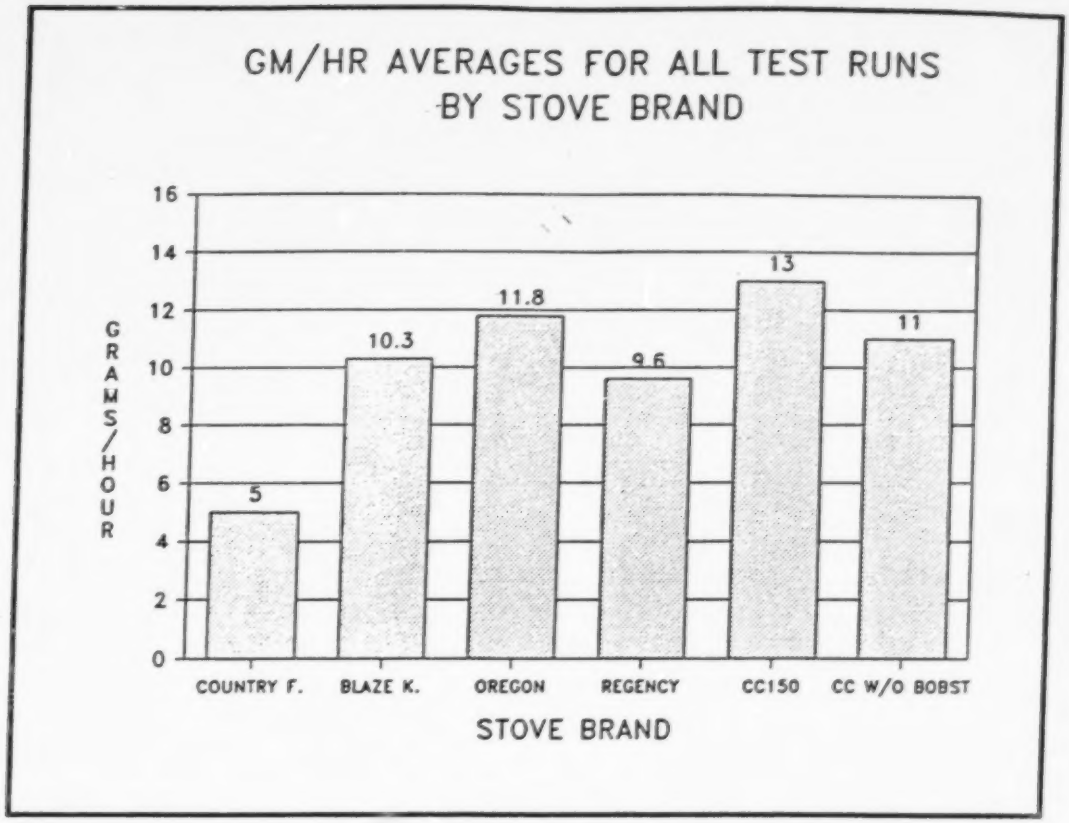
SUMMARY

The average particulate emissions for the burning season from the best performing catalytic woodstove, the Country Flame, was about 5 grams per hour. This represents a 75% decrease in emissions compared to conventional woodstoves. Two brands of non-catalytic stoves averaged about 10 grams per hour particulate emissions. This is about 50% better than conventional stoves.

The performance of these stoves demonstrates that some current technology is capable of reducing particulate emissions from woodstoves quite significantly.

The study also revealed that two of the catalytic brand stoves which had earlier passed a laboratory stress test did not perform up to expectations. The performance of the Blaze King Royal Heir degraded significantly. This was caused by sagging of unsupported bypass support areas as well as stove design-induced premature catalyst failure. The Oregon Woodstove had quality control problems with bypass sealing that caused poor performance throughout the test period.

The two non-catalytic did not display performance degradation but both developed some premature oxidation and warping problems in the primary combustion chamber.


GM/HR AVERAGES FOR ALL TEST RUNS
BY STOVE BRAND
GRAMS/HOUR
16
14
12
10
8
6
4
2
0
5
10.3
11.8
9.6
13
11
COUNTRY F.
BLAZE K.
OREGON
REGENCY
CC150
CC W/O BOBST
STOVE BRAND

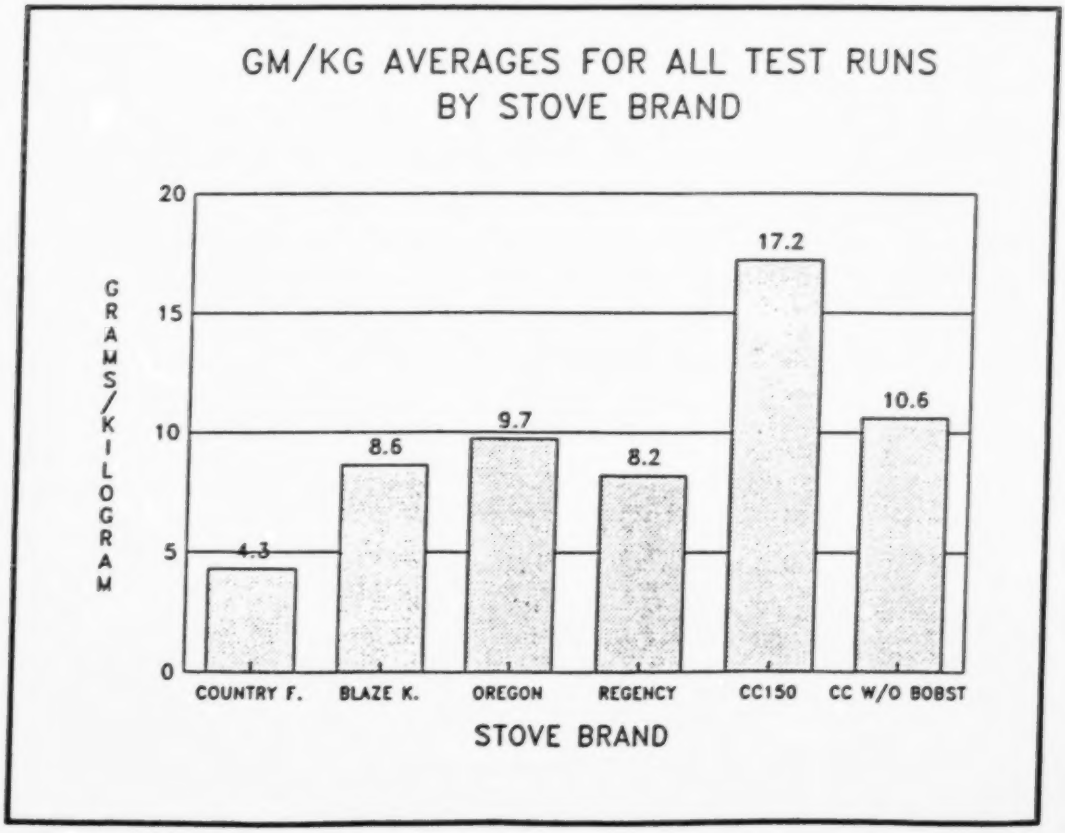

GM/KG AVERAGES FOR ALL TEST RUNS
BY STOVE BRAND
GRAMS/KILOGRAM
20
15
10
5
0
4.3
8.6
9.7
8.2
17.2
10.6
COUNTRY F.
BLAZE K.
OREGON
REGENCY
CC150
CC W/O BOBST
STOVE BRAND

FIGURE 1

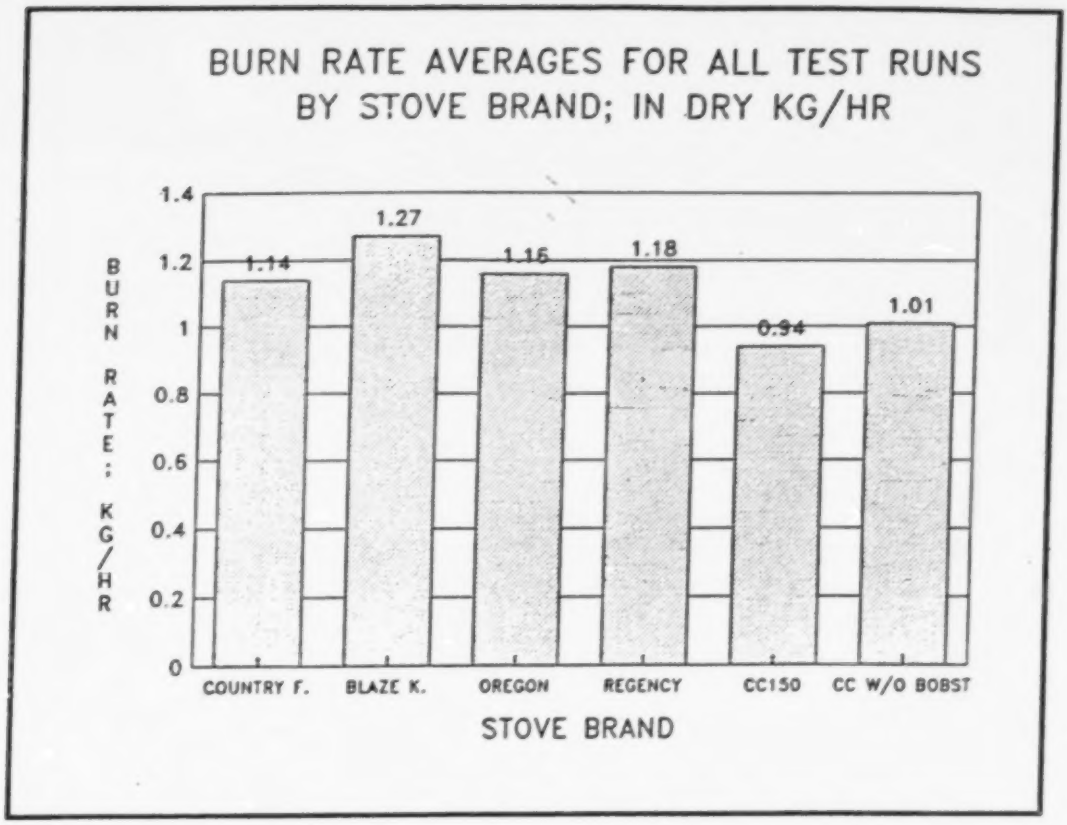
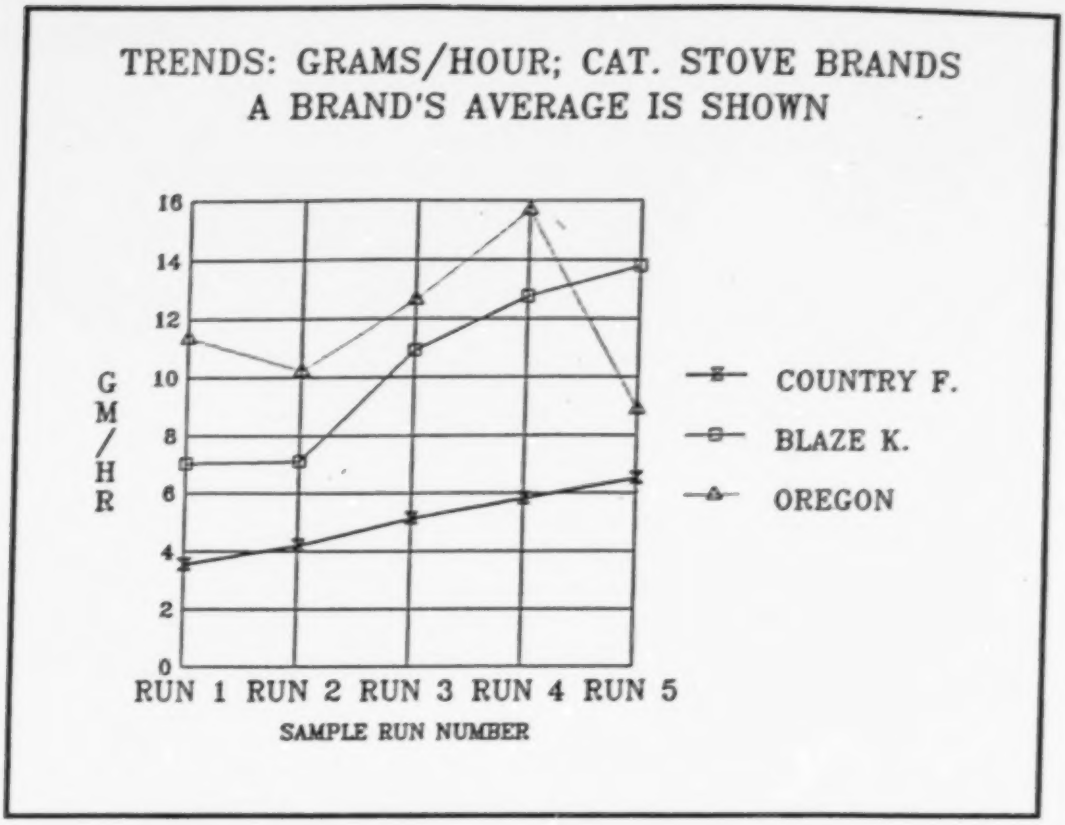

BURN RATE AVERAGES FOR ALL TEST RUNS
BY STOVE BRAND; IN DRY KG/HR
BURN RATE: KG/HR
1.4
1.2
1
0.8
0.6
0.4
0.2
0
1.14
1.27
1.16
1.18
0.94
1.01
COUNTRY F.
BLAZE K.
OREGON
REGENCY
CC150
CC W/O BOBST
STOVE BRAND

FIGURE 2


TRENDS: GRAMS/HOUR; CAT. STOVE BRANDS
A BRAND'S AVERAGE IS SHOWN
G M / H R
16
14
12
10
8
6
4
2
0
RUN 1 RUN 2 RUN 3 RUN 4 RUN 5
SAMPLE RUN NUMBER
COUNTRY F.
BLAZE K.
OREGON

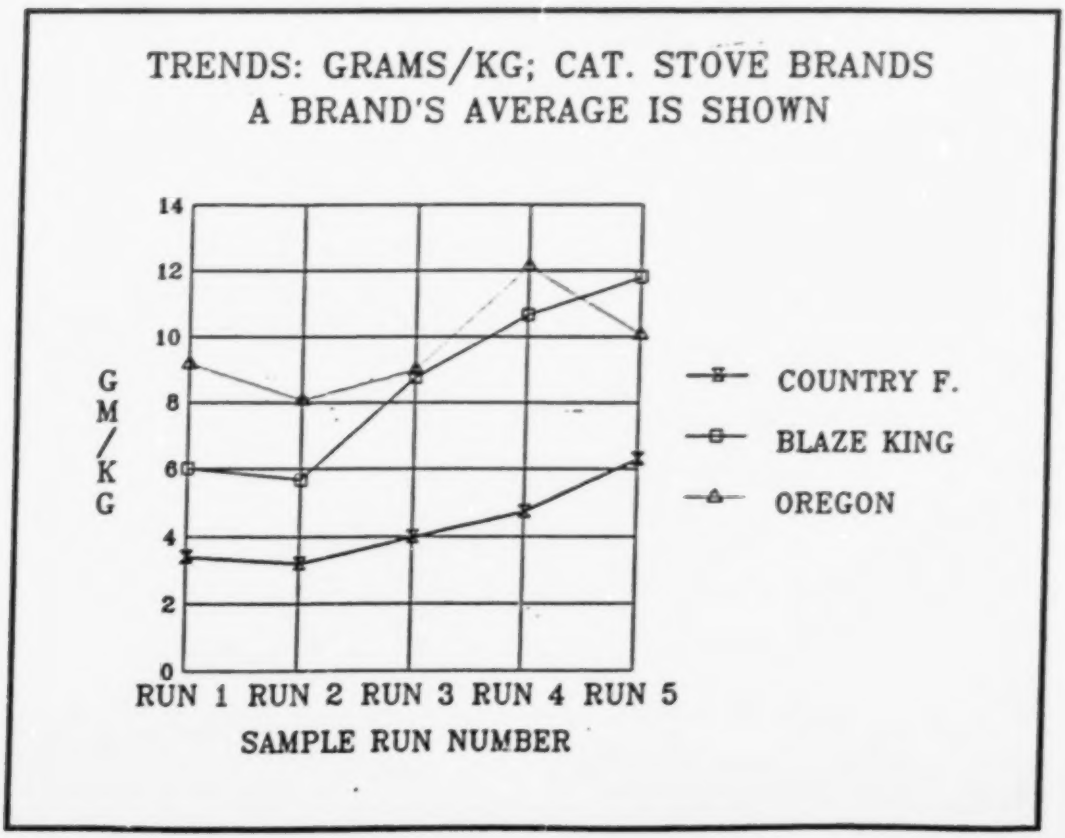
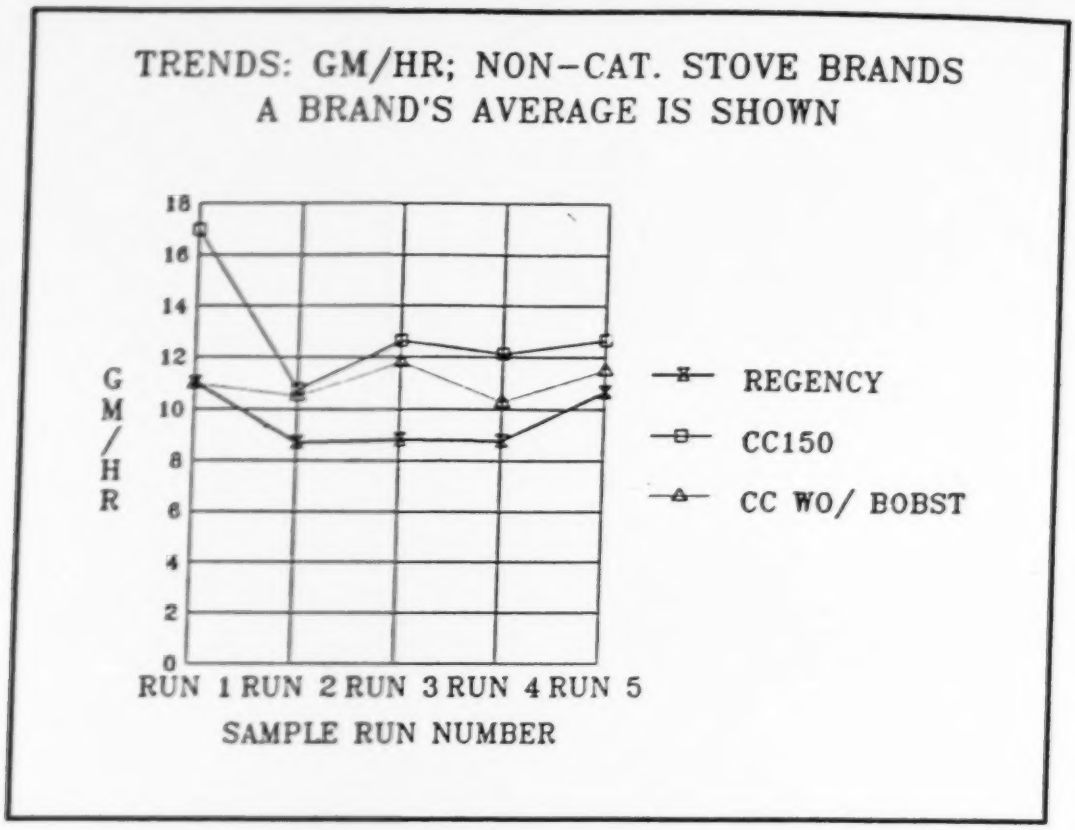

TRENDS: GRAMS/KG; CAT. STOVE BRANDS
A BRAND'S AVERAGE IS SHOWN
G M / K G
14
12
10
8
6
4
2
0
RUN 1 RUN 2 RUN 3 RUN 4 RUN 5
SAMPLE RUN NUMBER
COUNTRY F.
BLAZE KING
OREGON

FIGURE 3


TRENDS: GM/HR; NON-CAT. STOVE BRANDS
A BRAND'S AVERAGE IS SHOWN
GM/HR
18
16
14
12
10
8
6
4
2
0
RUN 1 RUN 2 RUN 3 RUN 4 RUN 5
SAMPLE RUN NUMBER
REGENCY
CC150
CC WO/ BOBST

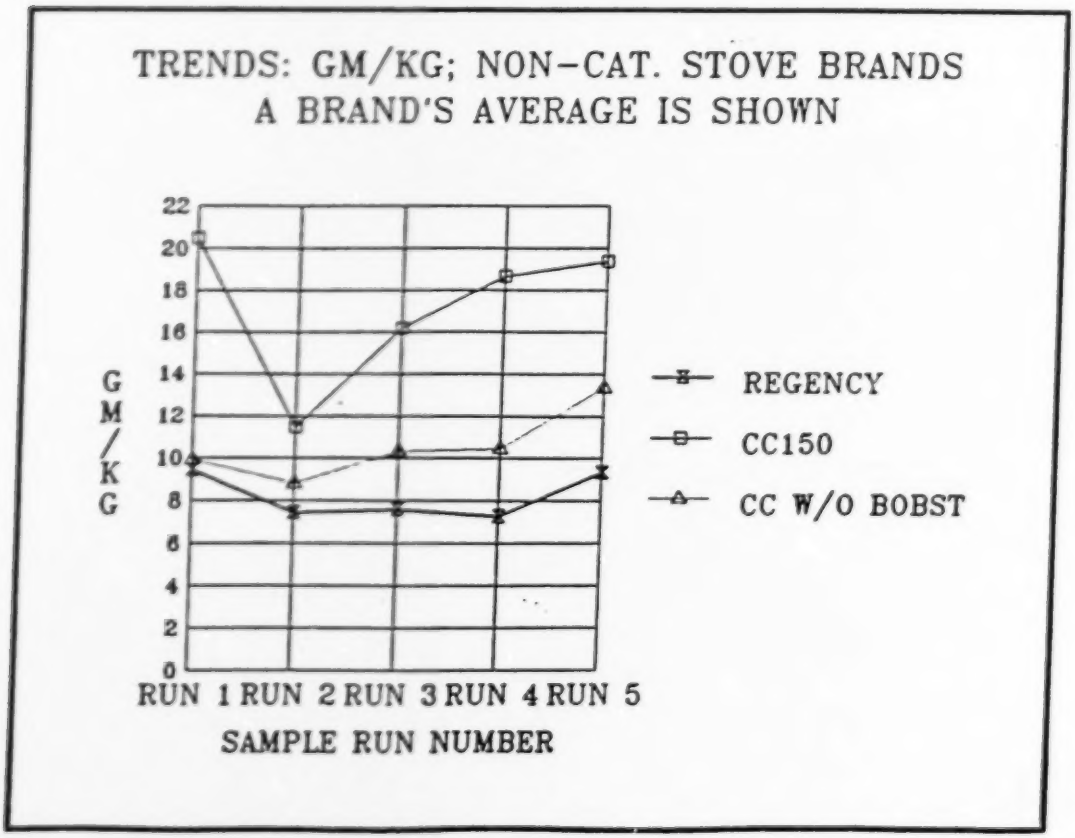
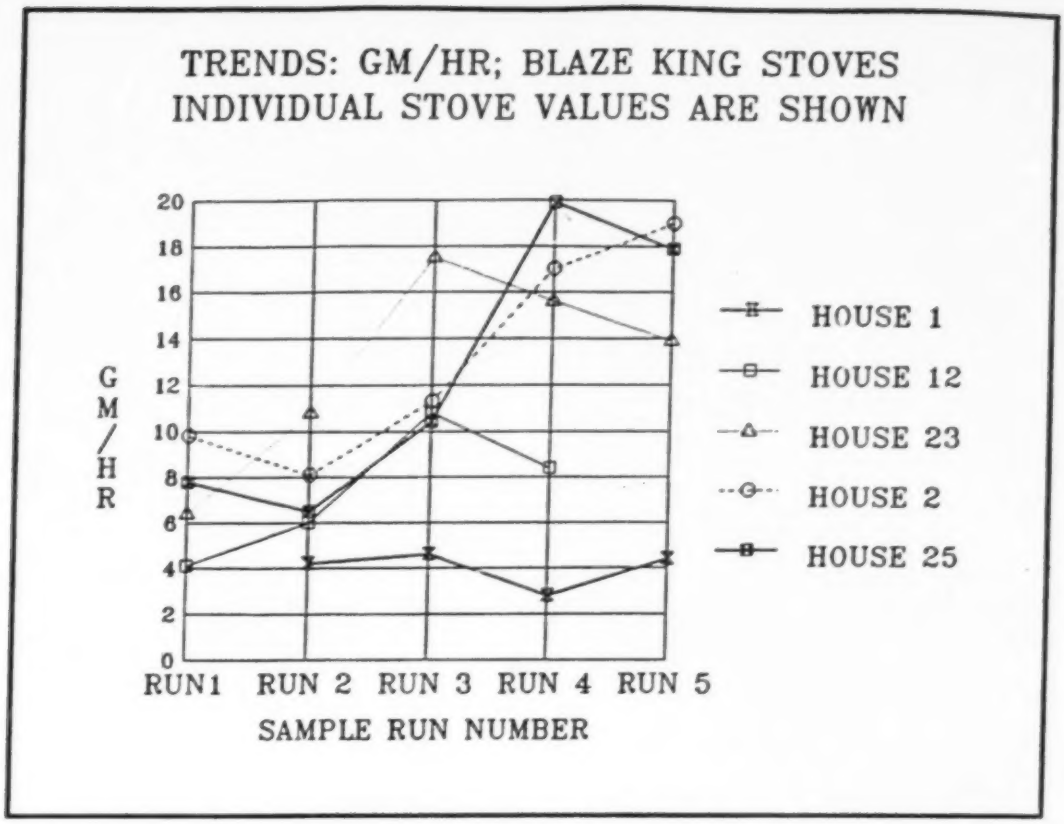

TRENDS: GM/KG; NON-CAT. STOVE BRANDS
A BRAND'S AVERAGE IS SHOWN
GM/KG
22
20
18
16
14
12
10
8
6
4
2
0
RUN 1 RUN 2 RUN 3 RUN 4 RUN 5
SAMPLE RUN NUMBER
REGENCY
CC150
CC W/O BOBST

FIGURE 4


TRENDS: GM/HR; BLAZE KING STOVES
INDIVIDUAL STOVE VALUES ARE SHOWN
GM/HR
20
18
16
14
12
10
8
6
4
2
0
RUN1 RUN 2 RUN 3 RUN 4 RUN 5
SAMPLE RUN NUMBER
HOUSE 1
HOUSE 12
HOUSE 23
HOUSE 2
HOUSE 25

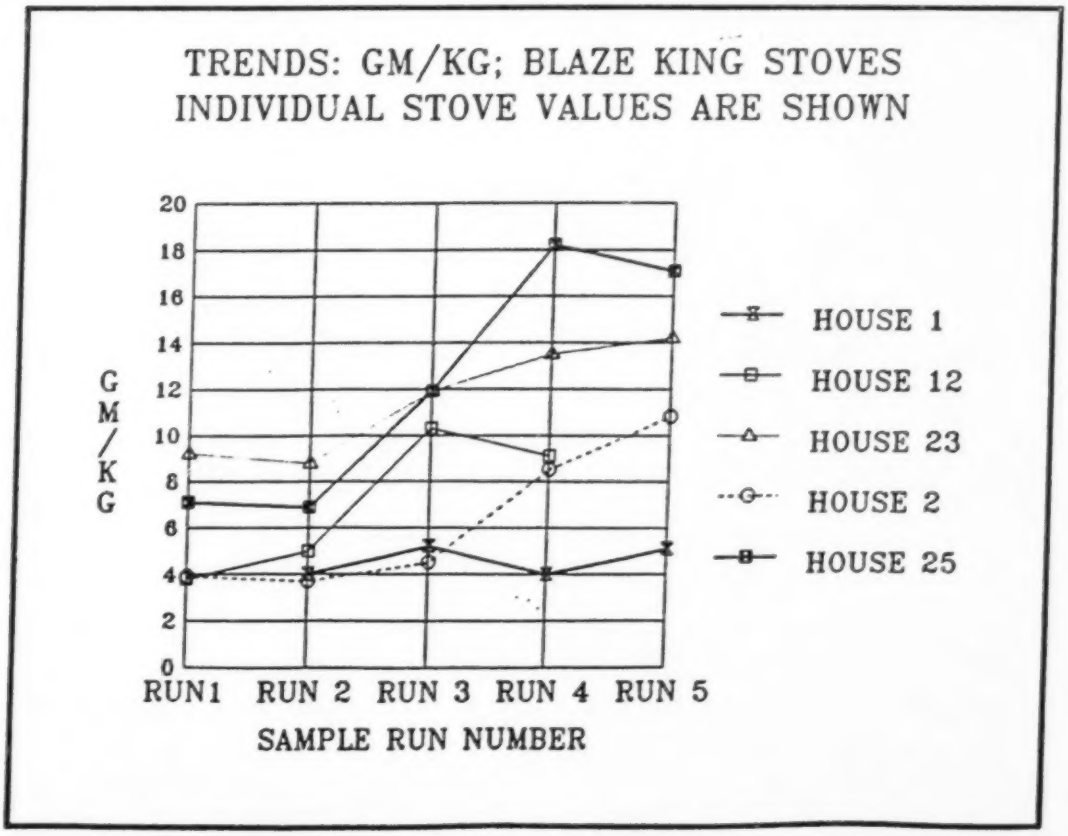
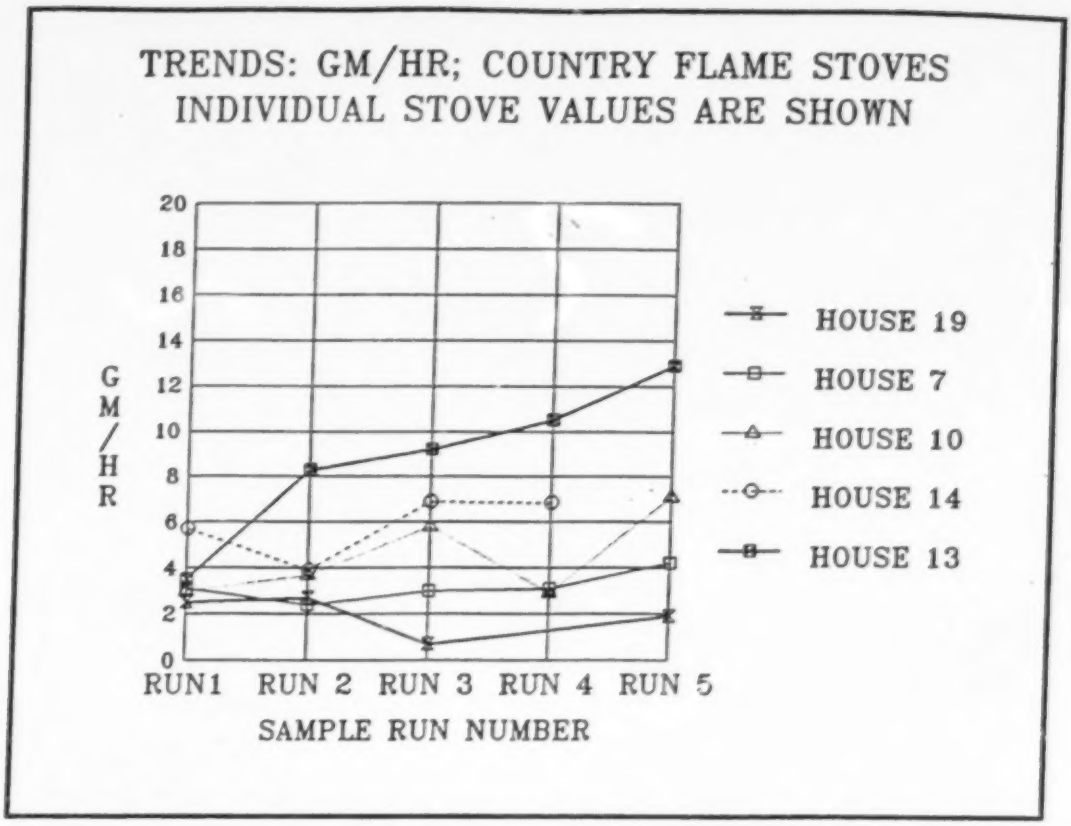

TRENDS: GM/KG; BLAZE KING STOVES
INDIVIDUAL STOVE VALUES ARE SHOWN
GM/KG
20
18
16
14
12
10
8
6
4
2
0
RUN1 RUN 2 RUN 3 RUN 4 RUN 5
SAMPLE RUN NUMBER
HOUSE 1
HOUSE 12
HOUSE 23
HOUSE 2
HOUSE 25

FIGURE 5


TRENDS: GM/HR; COUNTRY FLAME STOVES
INDIVIDUAL STOVE VALUES ARE SHOWN
GM/HR
20
18
16
14
12
10
8
6
4
2
0
RUN1 RUN 2 RUN 3 RUN 4 RUN 5
SAMPLE RUN NUMBER
HOUSE 19
HOUSE 7
HOUSE 10
HOUSE 14
HOUSE 13

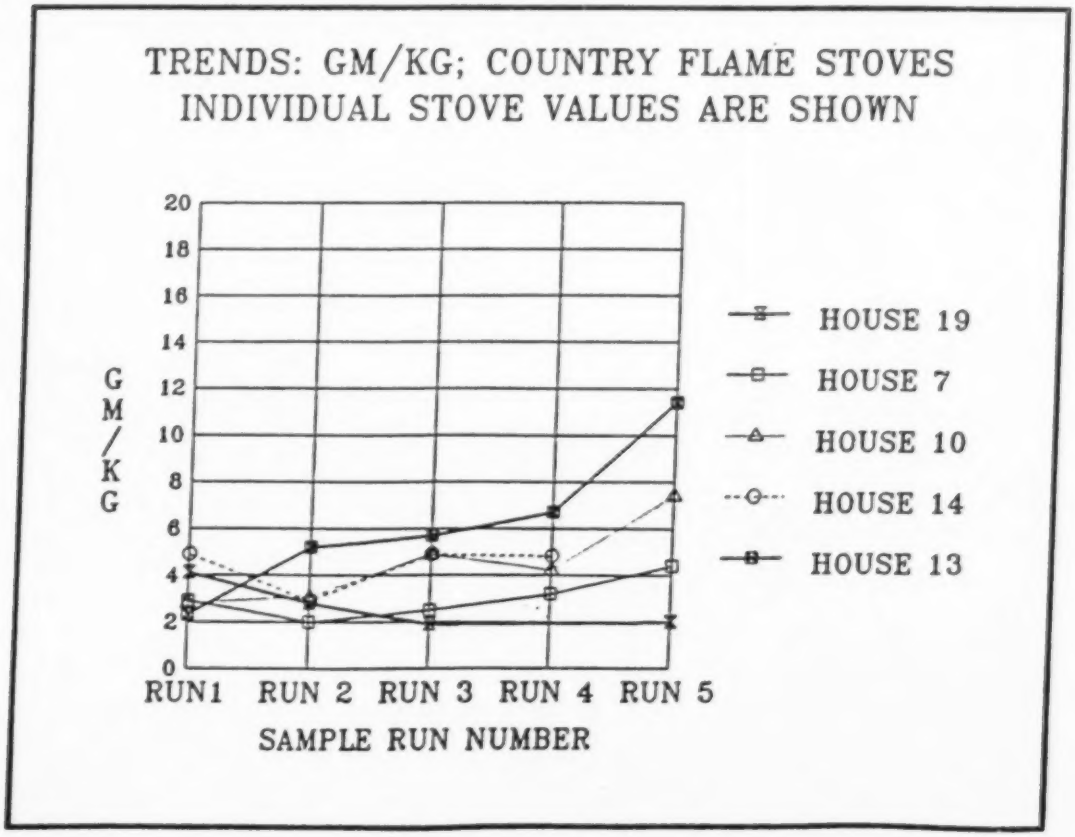
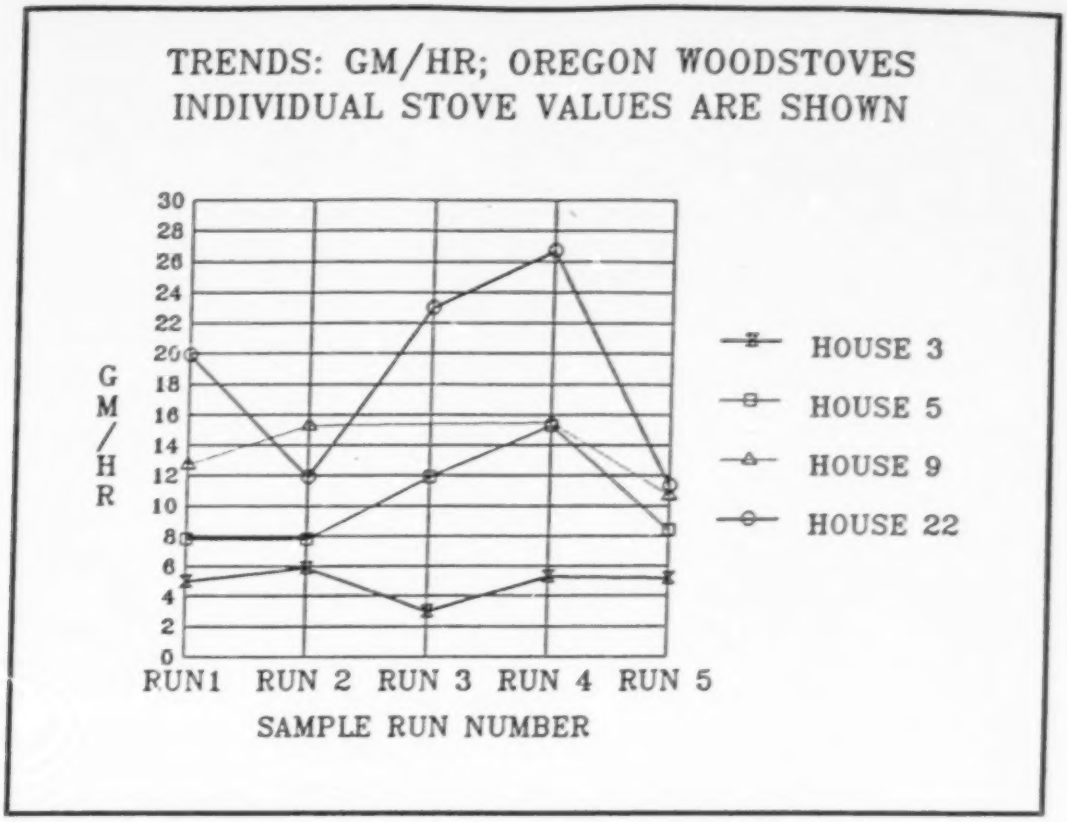

TRENDS: GM/KG; COUNTRY FLAME STOVES
INDIVIDUAL STOVE VALUES ARE SHOWN
GM/KG
20
18
16
14
12
10
8
6
4
2
0
RUN1 RUN 2 RUN 3 RUN 4 RUN 5
SAMPLE RUN NUMBER
HOUSE 19
HOUSE 7
HOUSE 10
HOUSE 14
HOUSE 13

FIGURE 6


TRENDS: GM/HR; OREGON WOODSTOVES
INDIVIDUAL STOVE VALUES ARE SHOWN
GM/HR
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
RUN1 RUN 2 RUN 3 RUN 4 RUN 5
SAMPLE RUN NUMBER
HOUSE 3
HOUSE 5
HOUSE 9
HOUSE 22

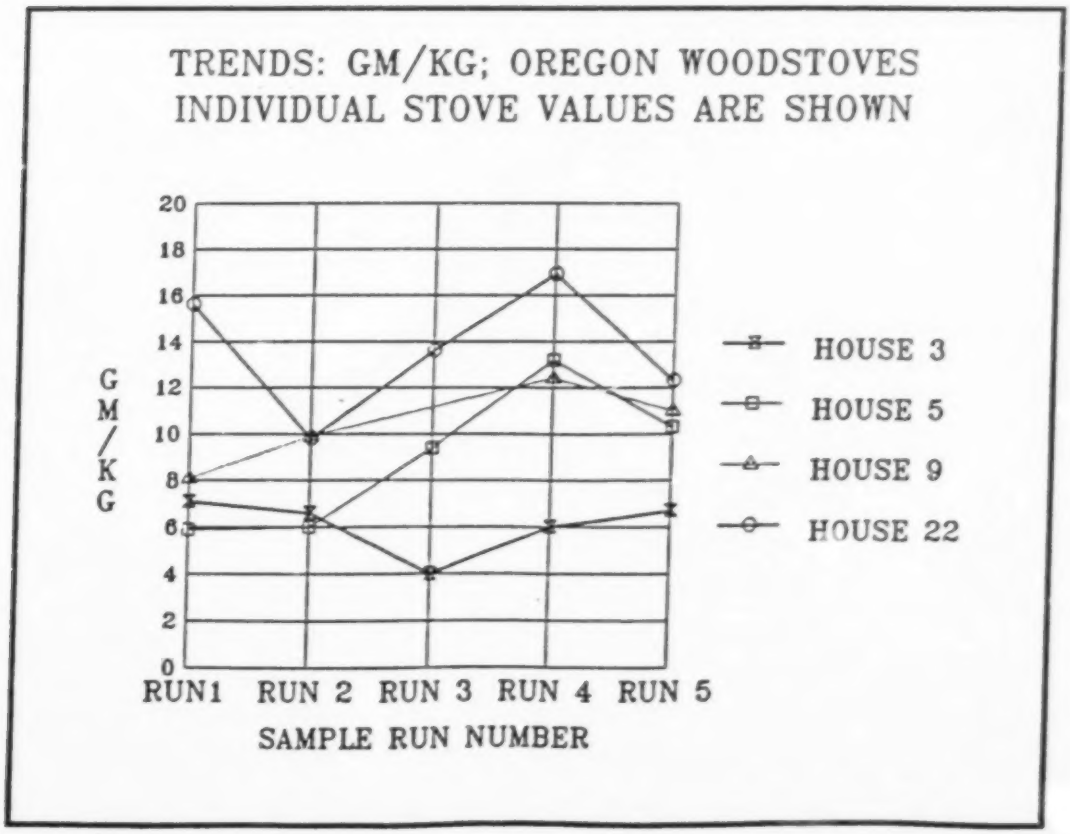
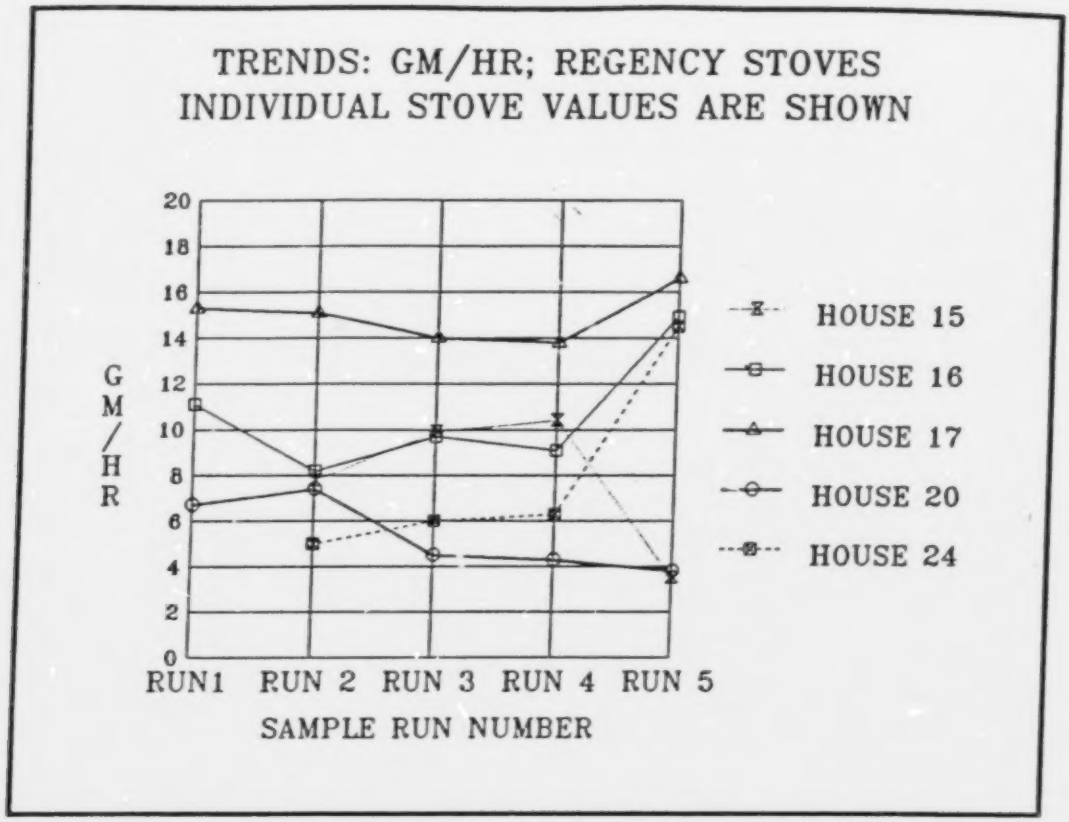

TRENDS: GM/KG; OREGON WOODSTOVES
INDIVIDUAL STOVE VALUES ARE SHOWN
GM/KG
20
18
16
14
12
10
8
6
4
2
0
RUN1 RUN 2 RUN 3 RUN 4 RUN 5
SAMPLE RUN NUMBER
HOUSE 3
HOUSE 5
HOUSE 9
HOUSE 22

FIGURE 7


TRENDS: GM/HR; REGENCY STOVES
INDIVIDUAL STOVE VALUES ARE SHOWN
GM/HR
20
18
16
14
12
10
8
6
4
2
0
RUN1 RUN 2 RUN 3 RUN 4 RUN 5
SAMPLE RUN NUMBER
HOUSE 15
HOUSE 16
HOUSE 17
HOUSE 20
HOUSE 24

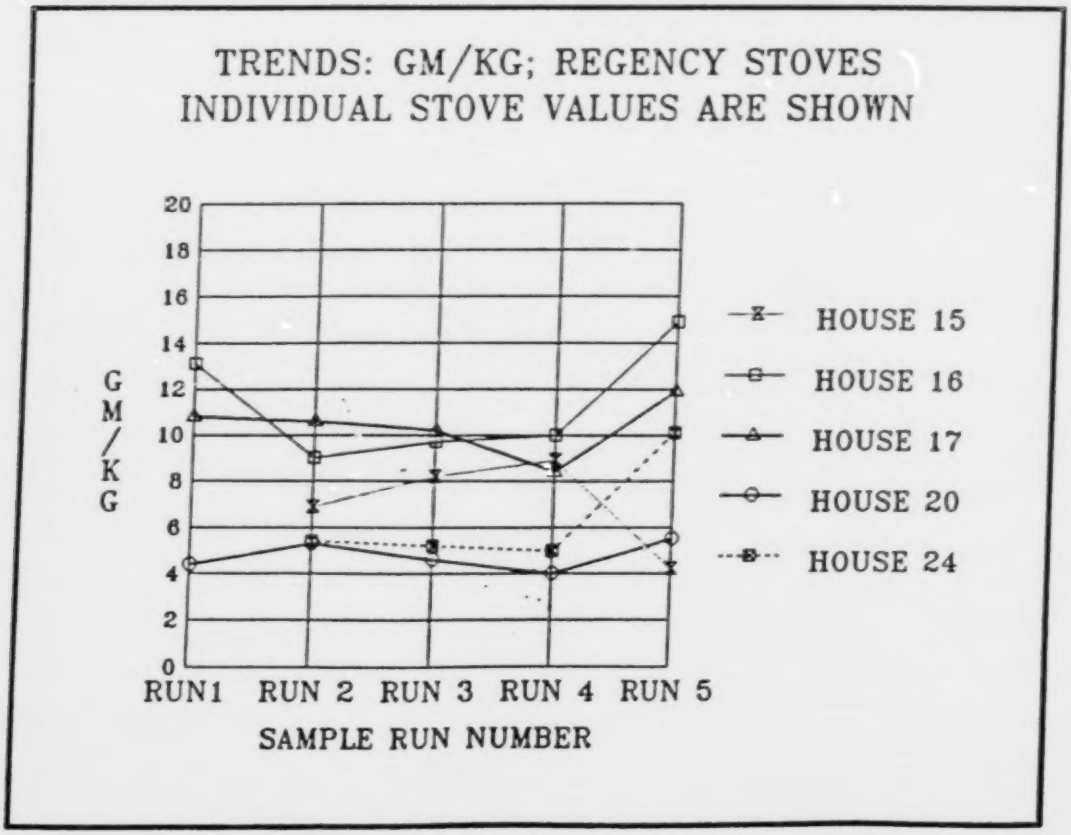
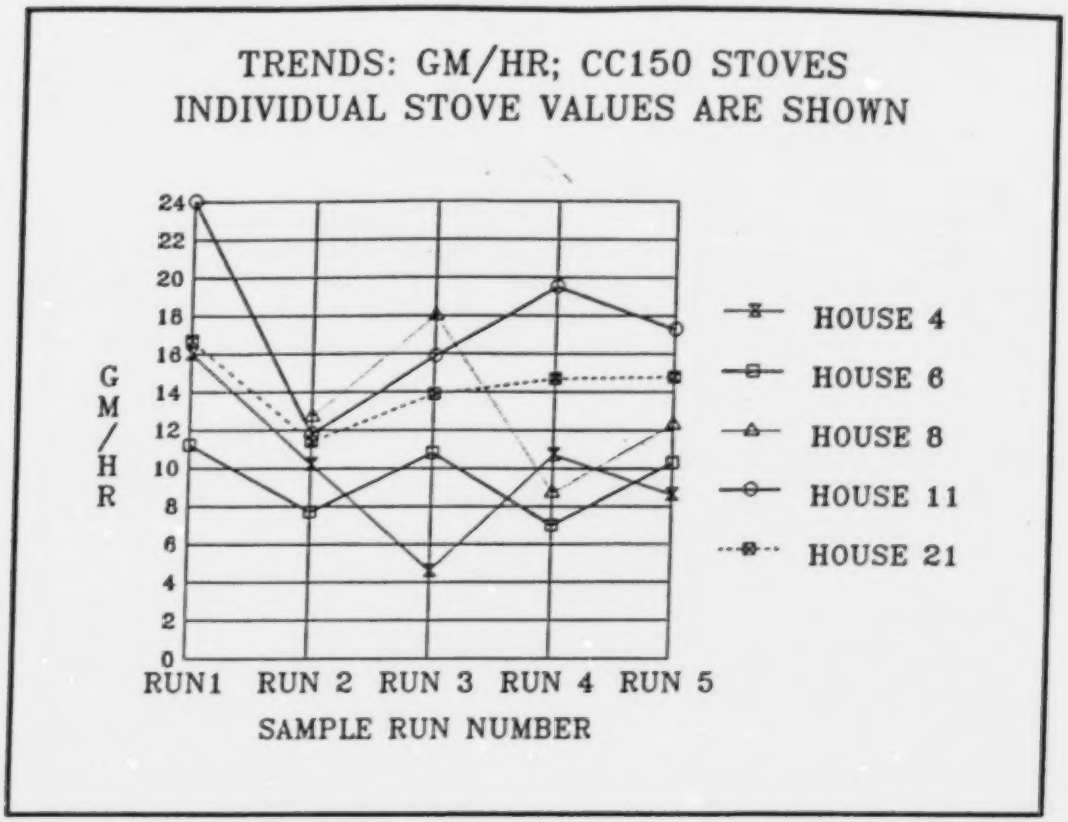

TRENDS: GM/KG; REGENCY STOVES
INDIVIDUAL STOVE VALUES ARE SHOWN
GM/KG
20
18
16
14
12
10
8
6
4
2
0
RUN1 RUN 2 RUN 3 RUN 4 RUN 5
SAMPLE RUN NUMBER
HOUSE 15
HOUSE 16
HOUSE 17
HOUSE 20
HOUSE 24

FIGURE 8


TRENDS: GM/HR; CC150 STOVES
INDIVIDUAL STOVE VALUES ARE SHOWN
GM/HR
0
2
4
6
8
10
12
14
16
18
20
22
24
RUN1
RUN 2
RUN 3
RUN 4
RUN 5
SAMPLE RUN NUMBER
HOUSE 4
HOUSE 6
HOUSE 8
HOUSE 11
HOUSE 21

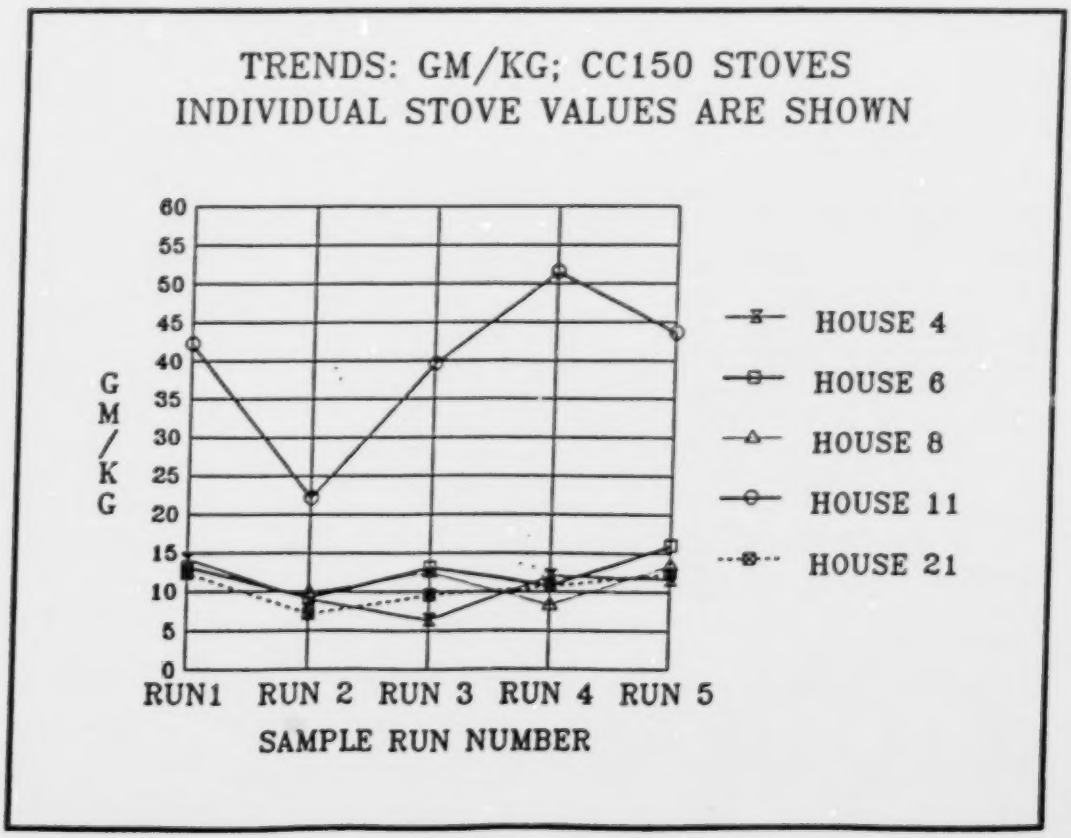

TRENDS: GM/KG; CC150 STOVES
INDIVIDUAL STOVE VALUES ARE SHOWN
GM/KG
0
5
10
15
20
25
30
35
40
45
50
55
60
RUN1
RUN 2
RUN 3
RUN 4
RUN 5
SAMPLE RUN NUMBER
HOUSE 4
HOUSE 6
HOUSE 8
HOUSE 11
HOUSE 21

FIGURE 9